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10/679,031	10/03/2003	Satoshi Komiya	90738	1669

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EXAMINER

SONG, MATTHEW J

ART UNIT	PAPER NUMBER
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1765

DATE MAILED: 03/10/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/679,031

Applicant(s)

KOMIYA ET AL.

Examiner

Matthew J Song

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– The MAILING DATE of this communication appears on the cover sheet with the correspondence address –

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 06 February 2004.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-41 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-41 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. _____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| Paper No(s)/Mail Date <u>2/6/04; 10/3/03</u> | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 1-18 and 30-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wijarankula (US 5,961,713) in view of Graef et al (US 5,935,320) or Tamatsuka et al (US 6,162,708).

Wijarankula discloses a silicon substrate 12 with a diameter of approximately 200 mm and includes a boron dopant of 3×10^{18} atoms/cm³ and approximately 23 ppma oxygen.

Wijarankula also discloses using semiconductor silicon substrates and epitaxial layers having wide ranges of thicknesses, dopants and dopant concentrations (col 4, ln 10-43). Wijarankula

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also discloses a typical microdefect 14 with a diameter greater than 0.1 micrometer (100 nm), this reads on applicant's LPDs, and growing a single crystal by the Czochralski method and slicing an ingot into semiconductor silicon wafers (col 4, ln 44-67). Wijarankula also discloses a process step 46 for depositing an epitaxial layer, where the epitaxial layer forms a microdefect-free layer 16 and the concentration of microdefects 14 decreases over a finite transition region 30 from a relatively high concentration in the substrate bulk to approximately zero (col 5, ln 1-67, col 6, ln 1-40 and Figs 2-3), this reads on applicant's LPDs of 120 nm or more is 20 pices/200 nm wafer or less.

Wijarankula does not disclose a substrate doped with nitrogen.

In a process for forming silicon semiconductor wafers, note entire reference, Graef et al teaches preparing a silicon single crystal having an oxygen concentration of at least $4 \times 10^{17}/\text{cm}^3$ and a nitrogen doping concentration of at least $1 \times 10^{14}/\text{cm}^3$ and processing the silicon single crystal to form silicon wafers with a low defect density (col 2, ln 40-67). Graef et al also teaches a single crystal produced according to the Cz method and processed to form silicon wafers comprising a nitrogen concentration of $3 \times 10^{14}/\text{cm}^3$ and an oxygen concentration was $9 \times 10^{17}/\text{cm}^3$ (col 5, ln 45-60), this reads on applicant's range of nitrogen and oxygen concentration in the silicon wafer substrate falls within an overlapping area in a graph in which the oxygen concentration and the nitrogen concentration are plotted along the horizontal axis and the vertical axis of the graph, respectively, on or below a first straight line connecting a point at which the nitrogen concentration is $3 \times 10^{15} \text{ atoms}/\text{cm}^3$ when the oxygen concentration is $7 \times 10^{17} \text{ atoms}/\text{cm}^3$ and a point at which the nitrogen concentration is $3 \times 10^{14} \text{ atoms}/\text{cm}^3$ when the oxygen concentration is $1.6 \times 10^{18} \text{ atoms}/\text{cm}^3$ and between vertical straight lines on which the oxygen

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concentration is 9×10^{17} atoms/cm³ and 1.6×10^{18} atoms/cm³, respectively because the concentrations for oxygen and nitrogen taught by Graef et al are within the claimed range. Graef et al also teaches the proportion of large defects decreases greatly with the increase in the degree of nitrogen doping (col 6, ln 10-20 and Example 2). Graef et al also teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarankula with Graef et al's nitrogen doped silicon substrate to reduce larger defects in the silicon substrate wafer.

In a process for forming an epitaxial silicon wafer, note entire reference, Tamatsuka et al teaches an epitaxial silicon single wafer characterized in that a silicon single crystal ingot which nitrogen is doped is grown by the Czochralski method and the resultant silicon single crystal ingot is sliced to produce a silicon single crystal wafer and then a epitaxial layer is formed in the surface layer portion of the resultant silicon single crystal wafer (col 2, ln 1-15). Tamatsuka et al also teaches when the nitrogen concentration of the silicon single crystal wafer is 1×10^{13} to 1×10^{14} atoms/cm³, it is possible to decrease the defect density on the surface of the epitaxial layer (col 4, ln 1-67). Tamatsuka et al also teaches an oxygen concentration less than 18 ppma (9×10^{17} atoms/cm³) (col 7, ln 40-45 and col 11, ln 30-35). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarankula with Tamatsuka's nitrogen doped silicon wafer to decrease the defect density on the surface of an epitaxial layer.

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The combination of Wijarankula and Tamatsuka et al does not teach the range of nitrogen concentration and oxygen concentration falls within an area in a graph in which the oxygen and nitrogen concentrations are plotted along the horizontal axis and vertical axis of the graph, respectively, on or below a straight line connecting a point at which the nitrogen concentration is 3×10^{15} atoms/cm³ when the oxygen concentration is 7×10^{17} atoms/cm³ and a point at which the nitrogen concentration is 3×10^{14} atoms/cm³ when the oxygen concentration is 1.6×10^{18} atoms/cm³. Graef et al teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45), this is a teaching that the relationship between the oxygen and nitrogen doping concentration is a result effective variable. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Wijarankula and Tamatsuka et al by optimizing the nitrogen and oxygen concentration to obtain same by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Furthermore, the combination of Wijarankula and Tamatsuka et al also teaches oxygen and nitrogen concentration ranges, which overlap the claimed range. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claim 2, the combination of Wijarankula and Tamatsuka et al and combination of Wijarankula and Graef et al does not teach the oxygen concentration and the nitrogen concentration are adjusted in a manner that the oxygen concentration and the nitrogen

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concentration have a predetermined correlative relationship of the nitrogen concentration increase corresponding to the oxygen concentration decrease and the nitrogen concentration decrease corresponding to the oxygen concentration increase such that the epitaxial silicon wafer has sufficient gettering sites. Graef et al teaches doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Wijarankula and Tamatsuka et al and combination of Wijarankula and Graef et al by optimizing the oxygen concentration in relation to the nitrogen concentration to obtain same by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

Referring to claim 2-3, Wijarankula teaches a microdefect size of greater than 0.1 micrometer (100 nm) or greater with a density of approximately zero for a 200 mm wafer. Overlapping ranges are held to be obvious (MPEP 2144.05).

3. Claims 4-9 and 35-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Graef et al (US 5,935,320).

In a process for forming silicon semiconductor wafers, note entire reference, Graef et al teaches preparing a silicon single crystal having an oxygen concentration of at least $4 \times 10^{17}/\text{cm}^3$

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and a nitrogen doping concentration of at least $1 \times 10^{14}/\text{cm}^3$ and processing the silicon single crystal to form silicon wafers with a low defect density (col 2, ln 40-67). Graef et al also teaches a single crystal produced according to the Cz method and processed to form silicon wafers comprising a nitrogen concentration of $3 \times 10^{14}/\text{cm}^3$ and an oxygen concentration was $9 \times 10^{17}/\text{cm}^3$ (col 5, ln 45-60), this reads on applicant's range of nitrogen and oxygen concentration in the silicon wafer substrate falls within an overlapping area in a graph in which the oxygen concentration and the nitrogen concentration are plotted along the horizontal axis and the vertical axis of the graph, respectively, on or below a first straight line connecting a point at which the nitrogen concentration is $3 \times 10^{15} \text{ atoms}/\text{cm}^3$ when the oxygen concentration is $7 \times 10^{17} \text{ atoms}/\text{cm}^3$ and a point at which the nitrogen concentration is $3 \times 10^{14} \text{ atoms}/\text{cm}^3$ when the oxygen concentration is $1.6 \times 10^{18} \text{ atoms}/\text{cm}^3$ and between vertical straight lines on which the oxygen concentration is $9 \times 10^{17} \text{ atoms}/\text{cm}^3$ and $1.6 \times 10^{18} \text{ atoms}/\text{cm}^3$, respectively because the concentrations for oxygen and nitrogen taught by Graef et al are within the claimed range. Graef et al also teaches the proportion of large defects decreases greatly with the increase in the degree of nitrogen doping (col 6, ln 10-20 and Example 2). Graef et al also teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45).

Graef et al also teaches oxygen and nitrogen concentration, which overlap the claimed ranges. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claim 4, Graef et al does not teach the nitrogen concentration increase gradually from a shoulder portion to a tail portion of the silicon single crystal ingot whereas the

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oxygen concentration decreases gradually from the shoulder portion to the tail portion. However, this feature is inherent to doped crystals pulled using the Czochralski method, as evidenced by Applicant's disclosure. Applicant's teach that when a silicon ingot is pulled from a silicon melt, unless the oxygen concentration, etc., is deliberately controlled, fluctuation of the nitrogen concentration caused by nitrogen segregation and fluctuation of the incorporated oxygen concentration resulting in a gradually increasing nitrogen concentration and a gradually decreasing oxygen concentration, note page 6, lines 15-25 of the instant specification. Graef et al does not teach any deliberate control of the oxygen or nitrogen concentration during the pulling process; therefore the gradually increasing nitrogen concentration and gradually decreasing oxygen concentration is inherent.

Referring to claim 5, Graef et al does not teach the nitrogen concentration in the tail portion is set less than 3×10^{15} atoms/cm³. Graef et al teaches pulling a silicon ingot using the Czochralski method, which inherently includes a tail region, with a nitrogen concentration of at least 1×10^{14} cm³, which overlaps the claimed range. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claims 6-7, Graef et al teaches a nitrogen concentration of 3×10^{14} /cm³ and an oxygen concentration of 9×10^{17} (col 5, ln 45-60) which is within the claimed range. Graef et al does not teach the oxygen concentration and the nitrogen concentration are adjusted in a manner that the oxygen concentration and the nitrogen concentration have a predetermined correlative relationship of the nitrogen concentration increase corresponding to the oxygen concentration decrease and the nitrogen concentration decrease corresponding to the oxygen concentration increase such that the epitaxial silicon wafer has sufficient gettering sites. Graef et al teaches

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doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the oxygen concentration in relation to the nitrogen concentration to obtain same by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

Referring to claim 9, claim 9 recites the oxygen concentration is controlled corresponding to a change in the nitrogen concentration, which is a method limitation in a product claim and does not further limit the product claim.

4. Claims 4-9 and 35-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tamatsuka et al (US 6,162,708).

Tamatsuka et al teaches an epitaxial silicon single wafer characterized in that a silicon single crystal ingot which nitrogen is doped to a concentration of 1×10^{10} to 5×10^{15} atoms/cm³ is grown by the Czochralski method and the resultant silicon single crystal ingot is sliced to produce a silicon single crystal wafer (col 2, ln 1-67). Tamatsuka et al also teaches the oxygen concentration is 18 ppma (9×10^{17} atoms/cm³) or less (col 4, ln 1-25).

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Tamatsuka et al does not teach the range of nitrogen concentration and oxygen concentration falls within an area in a graph in which the oxygen and nitrogen concentrations are plotted along the horizontal axis and vertical axis of the graph, respectively, on or below a straight line connecting a point at which the nitrogen concentration is 3×10^{15} atoms/cm³ when the oxygen concentration is 7×10^{17} atoms/cm³ and a point at which the nitrogen concentration is 3×10^{14} atoms/cm³ when the oxygen concentration is 1.6×10^{18} atoms/cm³. Graef et al teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45), this is a teaching that the relationship between the oxygen and nitrogen doping concentration is a result effective variable. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Tamatsuka et al by optimizing the nitrogen and oxygen concentration to obtain same by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Tamatsuka et al also teaches oxygen and nitrogen concentration, which overlap the claimed ranges. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claim 4, Tamatsuka et al does not teach the nitrogen concentration increase gradually from a shoulder portion to a tail portion of the silicon single crystal ingot whereas the oxygen concentration decreases gradually from the shoulder portion to the tail portion. However, this feature is inherent to doped crystals pulled using the Czochralski method, as evidenced by

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Applicant's disclosure. Applicant's teach that when a silicon ingot is pulled from a silicon melt, unless the oxygen concentration, etc., is deliberately controlled, fluctuation of the nitrogen concentration caused by nitrogen segregation and fluctuation of the incorporated oxygen concentration resulting in a gradually increasing nitrogen concentration and a gradually decreasing oxygen concentration, note page 6, lines 15-25 of the instant specification. Tamatsuka et al does not teach any deliberate control of the oxygen or nitrogen concentration during the pulling process; therefore the gradually increasing nitrogen concentration and gradually decreasing oxygen concentration is inherent.

Referring to claim 5, Tamatsuka et al does not teach the nitrogen concentration in the tail portion is set less than 3×10^{15} atoms/cm³. Tamatsuka et al teaches pulling a silicon ingot using the Czochralski method, which inherently includes a tail region, with a nitrogen concentration of less than 5×10^{15} atoms/cm³ (col 2, ln 30-40), which overlaps the claimed range. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claims 6-7, Graef et al teaches a nitrogen concentration of 3×10^{14} /cm³ and an oxygen concentration of 9×10^{17} (col 5, ln 45-60) which is within the claimed range. Graef et al does not teach the oxygen concentration and the nitrogen concentration are adjusted in a manner that the oxygen concentration and the nitrogen concentration have a predetermined correlative relationship of the nitrogen concentration increase corresponding to the oxygen concentration decrease and the nitrogen concentration decrease corresponding to the oxygen concentration increase such that the epitaxial silicon wafer has sufficient gettering sites. Graef et al teaches doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same

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nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the oxygen concentration in relation to the nitrogen concentration to obtain same by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

Referring to claim 9, claim 9 recites the oxygen concentration is controlled corresponding to a change in the nitrogen concentration, which is a method limitation in a product claim and does not further limit the product claim.

5. Claims 19-29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wijarankula (US 5,961,713) in view of Graef et al (US 5,935,320) or Tamatsuka et al (US 6,162,708) as applied to claims 1-18 and 30-41 above, and further in view of Hakomori (JP 11-90803 A), where US 6,261,160 is used as an accurate translation, or in view of Hakomori (US 6,261,160).

The combination of Wijarankula and Graef et al or the combination of Wijarankula and Tamatsuka et al teach all of the limitations of claim 19, as discussed previously, except grinding the silicon wafer substrate.

Hakomori teaches a silicon wafer generally has its periphery chamfered to prevent chipping of its edge and crown during epitaxial growth and the chamfering is done by polishing the wafer with a diamond grindstone ('160 col 1, ln 10-55), this reads on applicant's grinding. It

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would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Wijarankula and Graef et al or the combination of Wijarankula and Tamatsuka et al by grinding the wafer prior to epitaxial growth to prevent chipping, as taught by Hakomori.

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Krishna et al (US 5,571,373) teaches polishing a semiconductor wafer to reduce LPDs to about 7 per wafer (col 7, ln 30-67).

Kobayashi et al (US 6,245,311) teaches a heat treatment to obtain a silicon wafer having the number of LPDs not less than 0.12 micrometers of 20 COPs/8 inch wafer (col 11, ln 1-50).

Wilson et al (US 6,284,384) teaches a correlation between atoms/cm³ of oxygen to ppm, where 9×10^{17} atoms/cm³ is equivalent to 18 ppm (col 8, ln 60-67 and col 9, ln 1-15) and a wafer with defects of 0.12 micrometers is less than 0.5/cm² (col 16).

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew J Song
Examiner
Art Unit 1765

MJS
February 25, 2005

NADINE G. NORTON
SUPERVISORY PATENT EXAMINER

